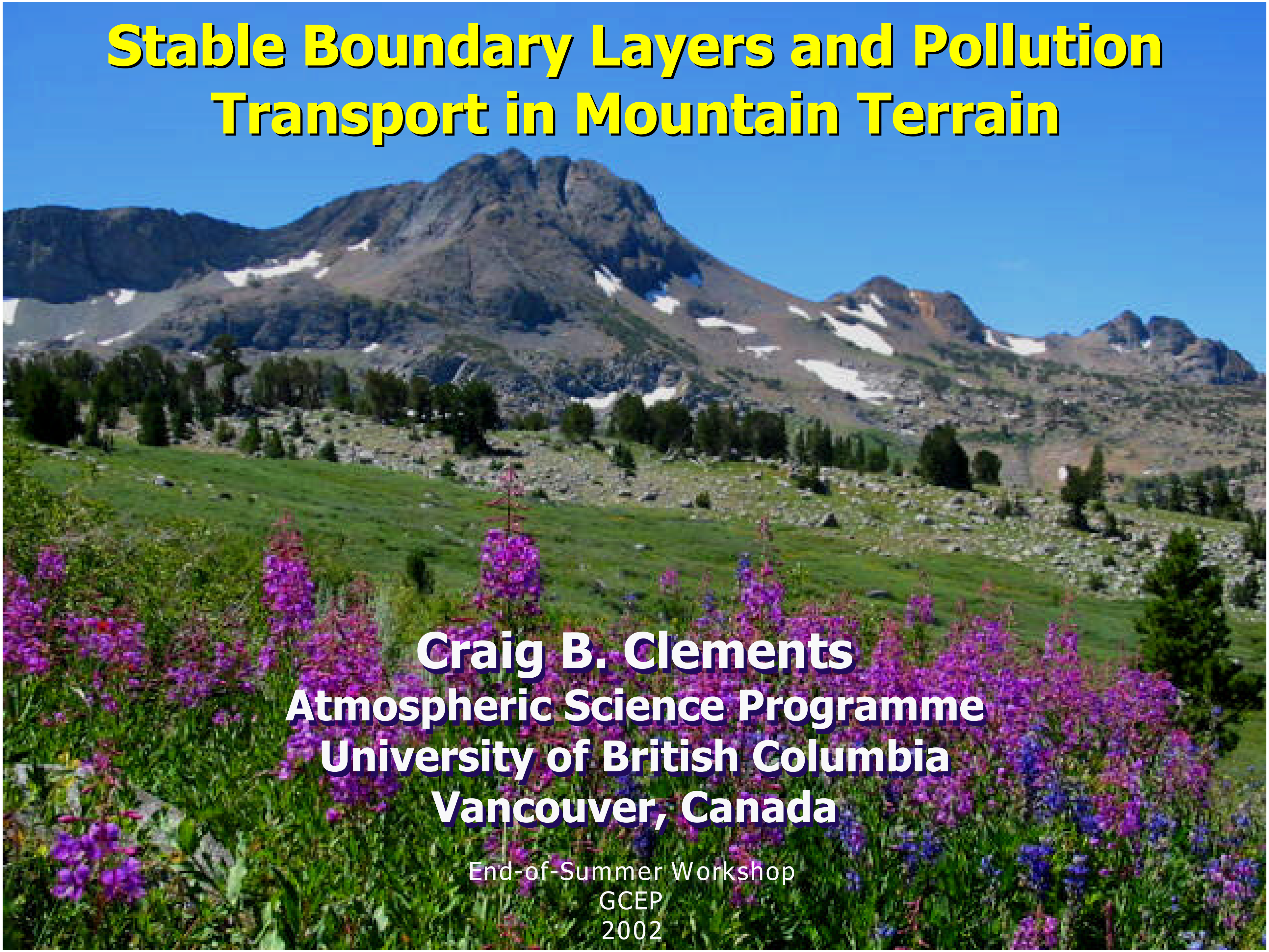

Stable Boundary Layers and Pollution Transport in Mountain Terrain

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End-of-Summer Workshop

GCEP

2002

Overview

1) **Introduction: Boundary Layer and Stability Basics**

2) **Why is mountain meteorology important?**

3) **Observations**

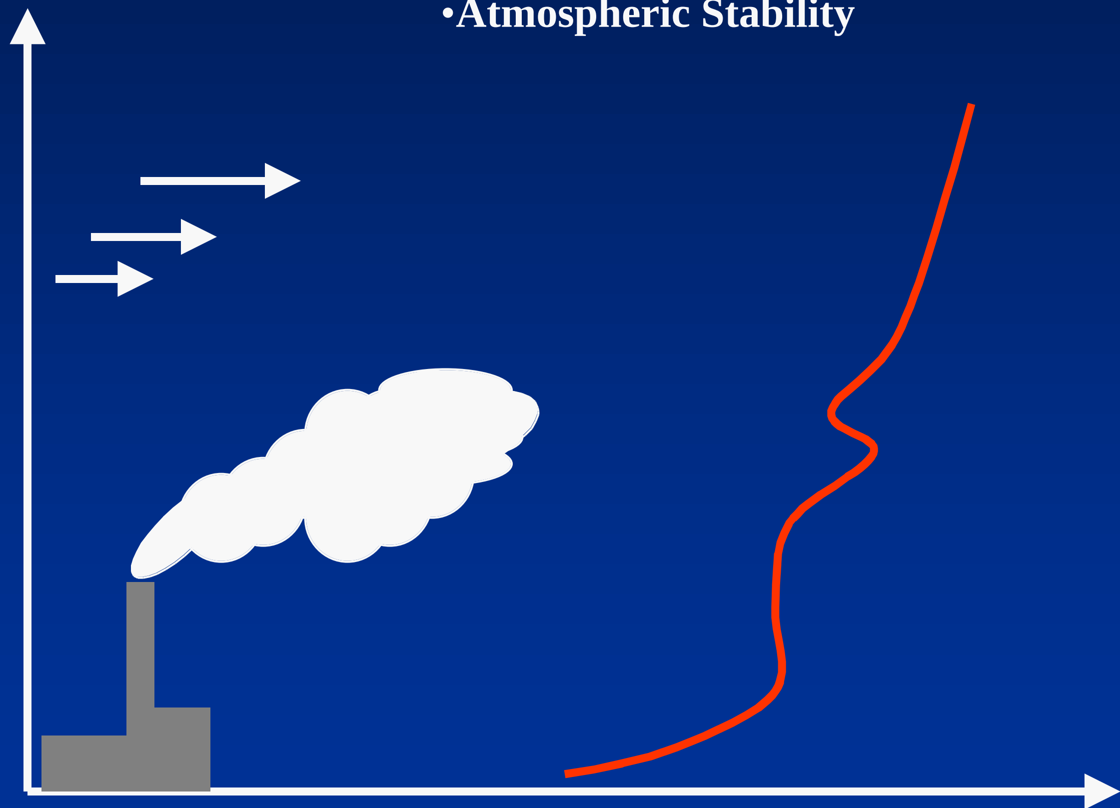
- **Yosemite National Park, Sierra Nevada**
- **Peter Sinks, Utah**
- **Monson Vineyard, WA**

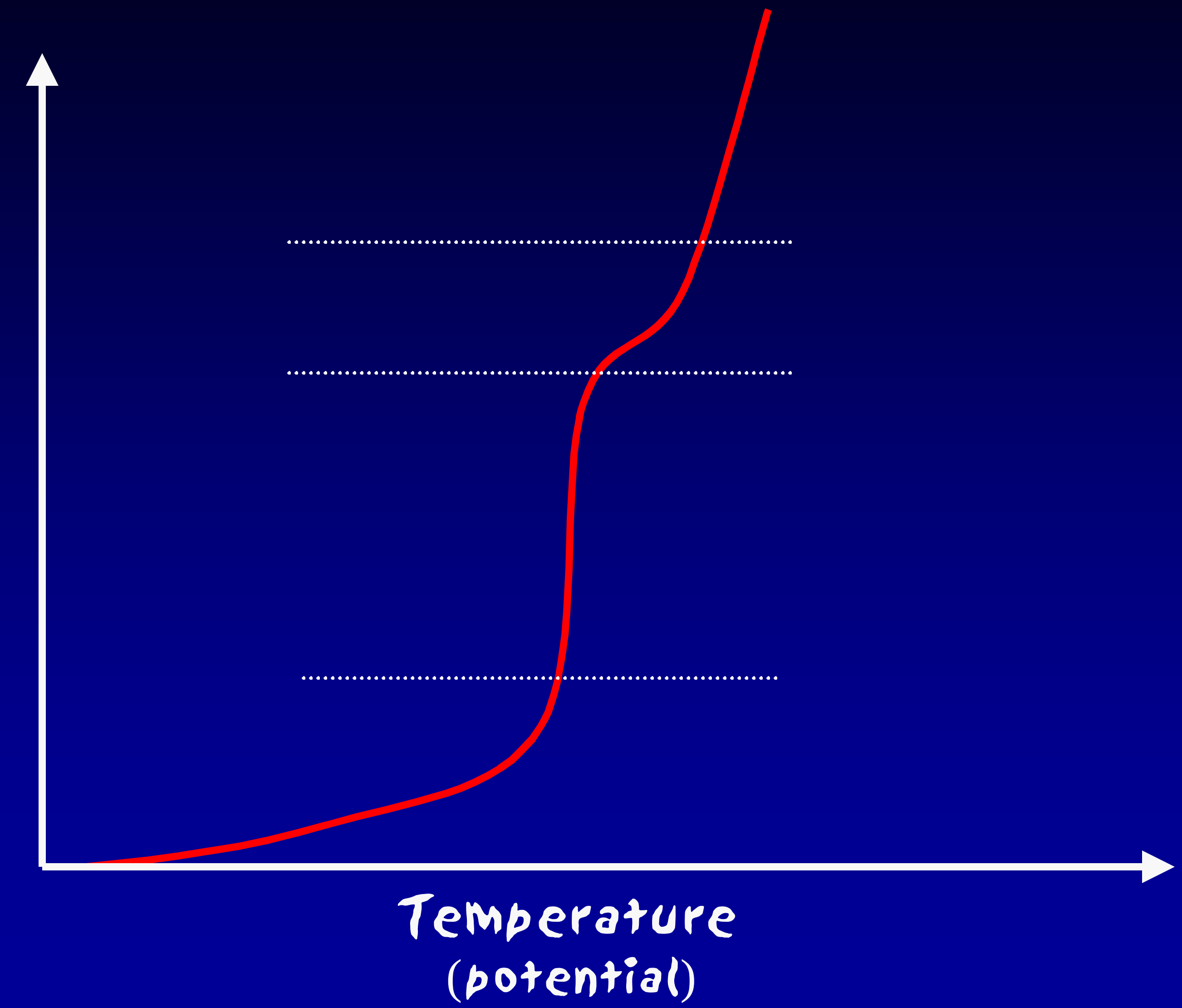
4) **Summary**

Air Pollution Meteorology- Basics

Pollution Dispersion:

- **Wind speed and Direction**
- **Plume rise**
- **Turbulence**
- **Atmospheric Stability**




Temperature
(potential)

What is Mountain Meteorology?

Tioga Pass, CA
Winter 1995

Lee Vining Canyon, eastern Sierra Nevada

Pilot Balloon Release- LVC, Sierra Nevada

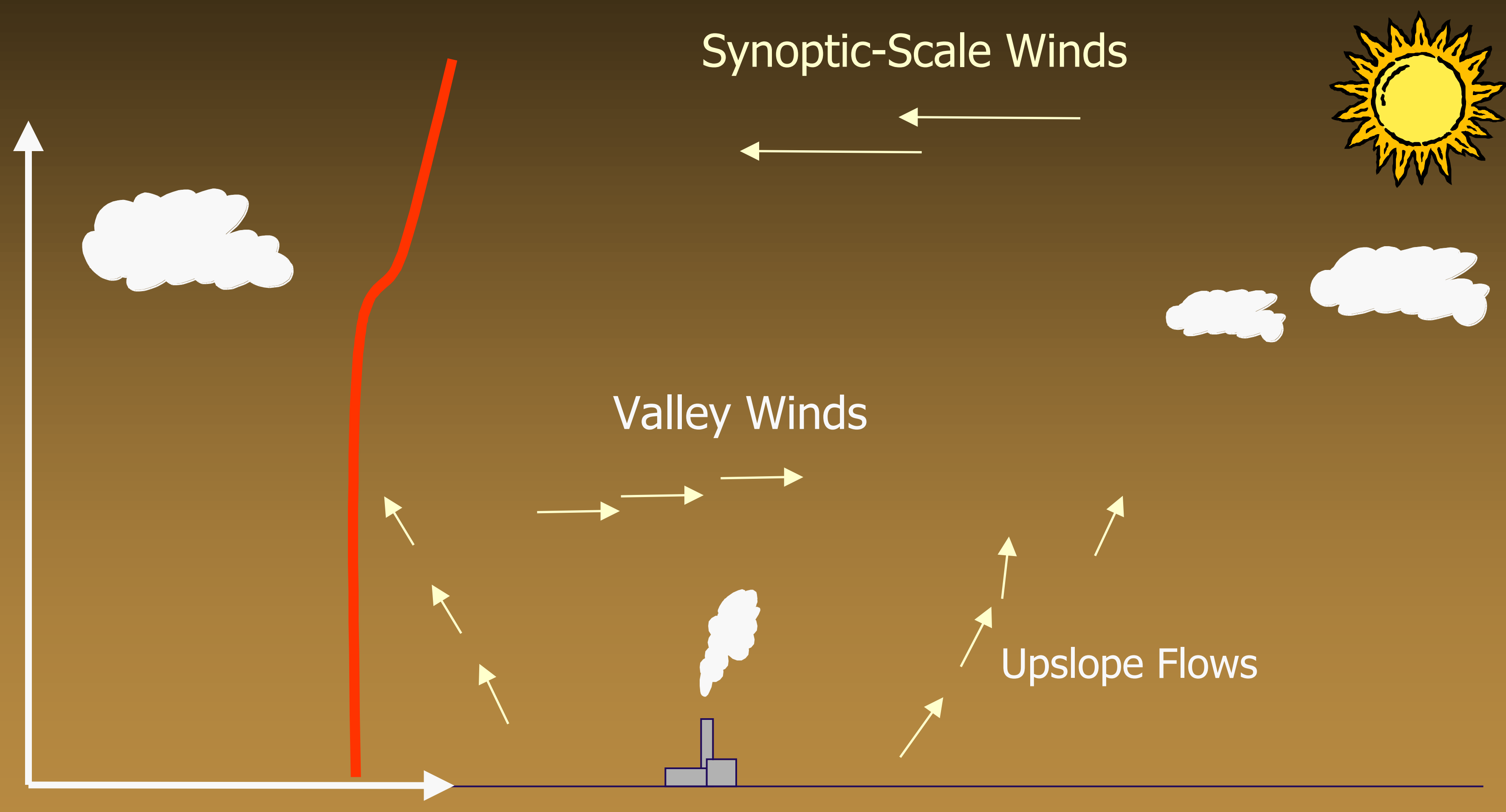
No-Lift Balloons at Tioga Pass, Sierra Nevada

Why is mountain meteorology important?

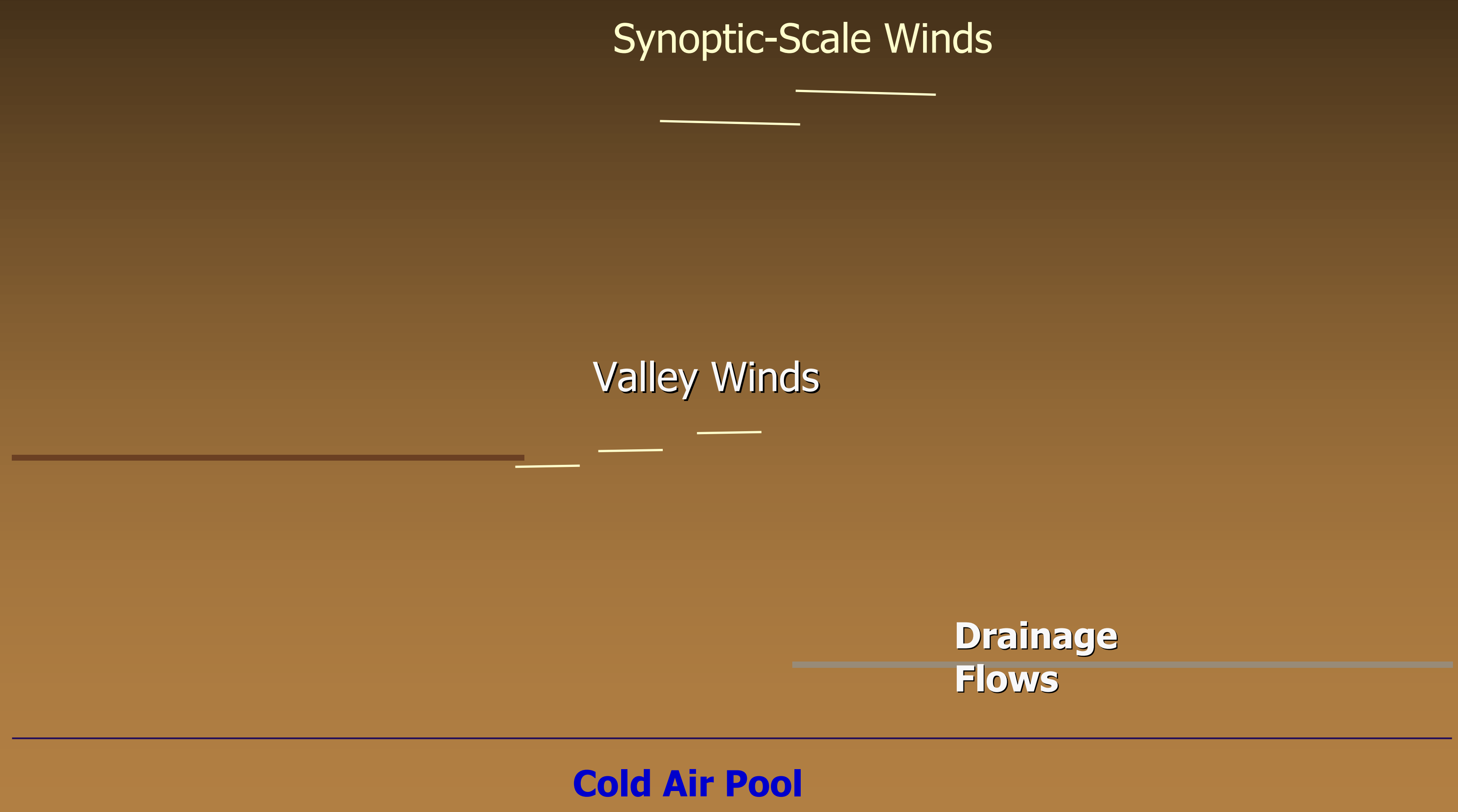
The Western US

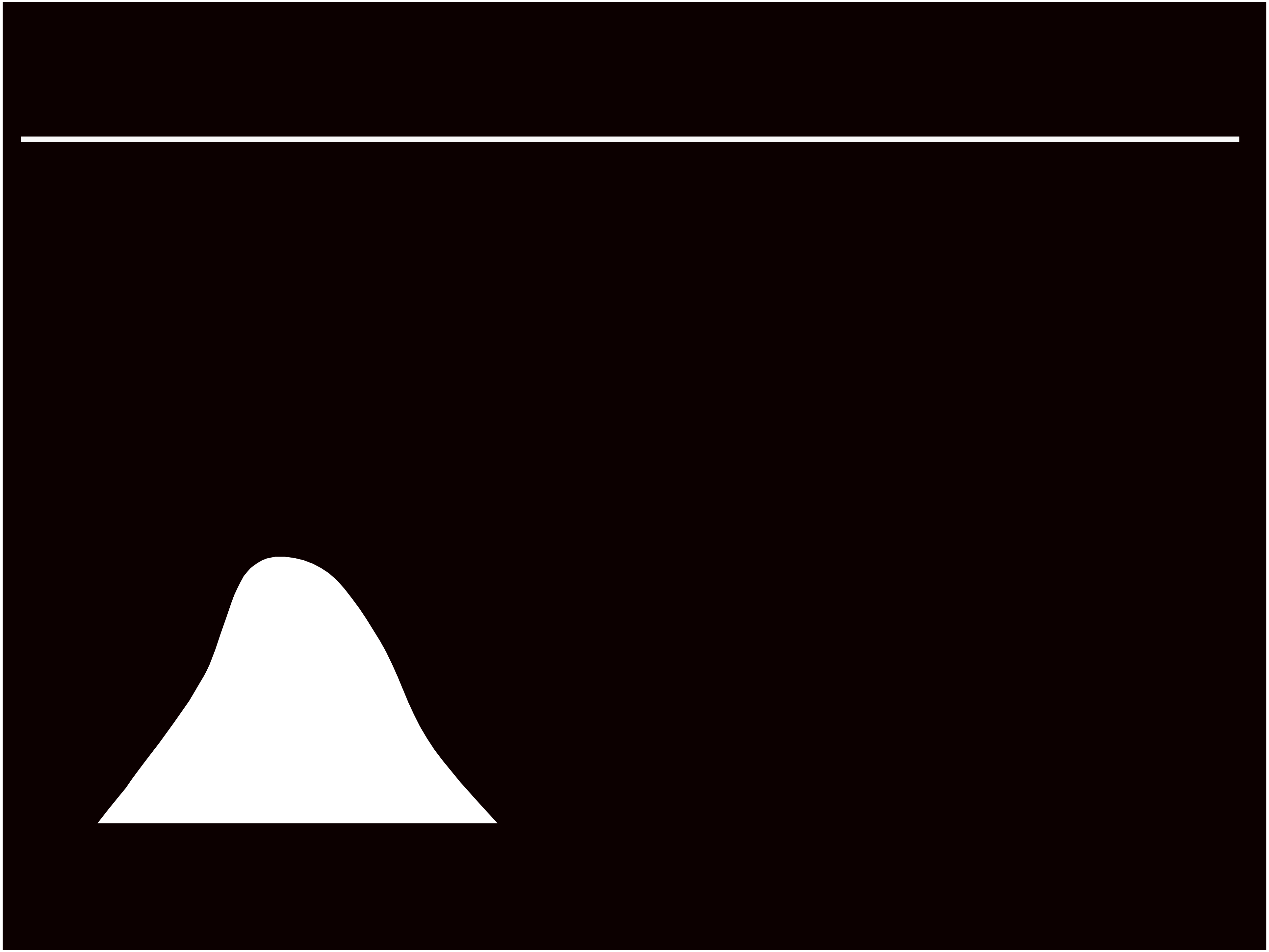
Mountain Meteorology: Applications for Air Pollution

Daytime- Late Afternoon



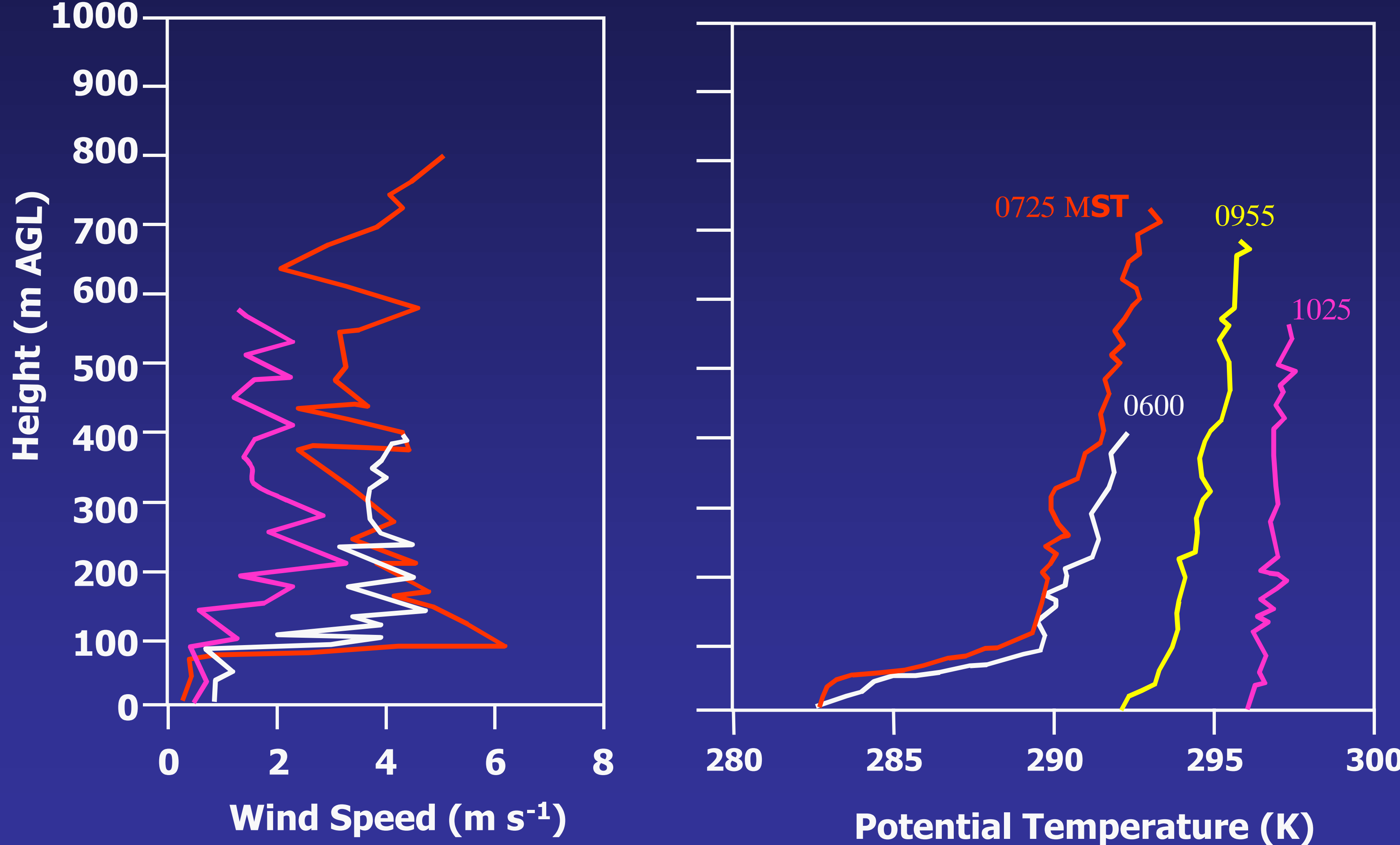
Early Evening





Tethersonde in Yosemite Valley, Sierra Nevada

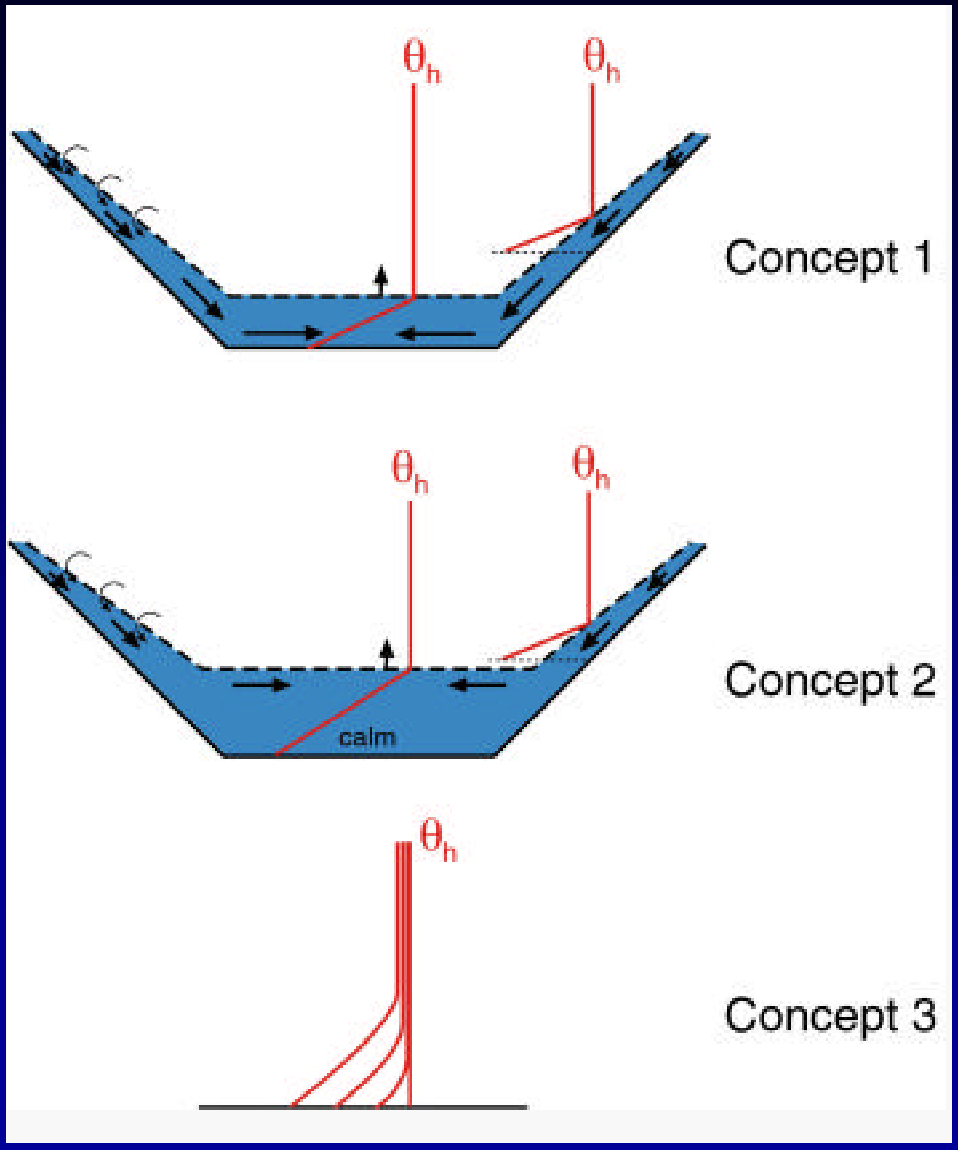
Vertical Profiles – Yosemite Valley (March 16, 1998)



Campfire smoke plume – Cayuse Creek, ID

Polluted CBL: Coast Mountains, British Columbia

Concepts of cold pool buildup



Valley/basin heat budget

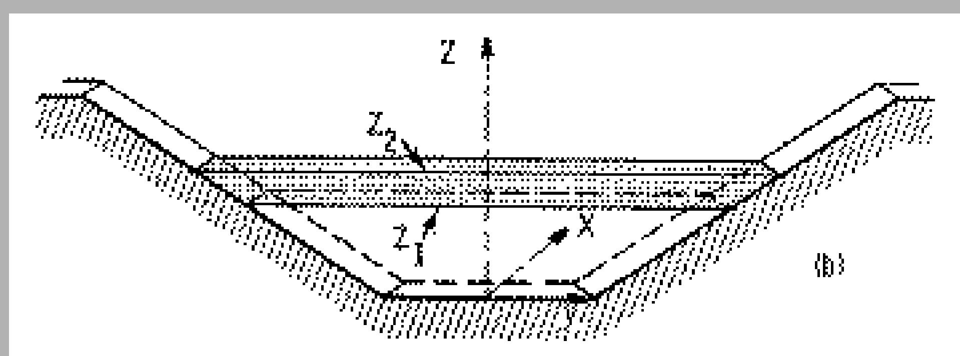
$$\underbrace{\overline{\rho}\, c_p \frac{\partial \theta}{\partial t} dv}_{A} = \underbrace{-\overline{\rho}\, c_p \nabla\cdot(\overline{\mathbf{V}}\,\overline{\theta})\, dv}_{B} + \underbrace{-\frac{\overline{\theta}}{\overline{T}} \nabla\cdot \overline{\mathbf{R}}\, dv}_{C} + \underbrace{-\overline{\rho}\, c_p \nabla\cdot(\overline{\mathbf{V}'\theta'})\, dv}_{D}$$

Term A : Rate of change of potential temperature (**Heat Storage)**

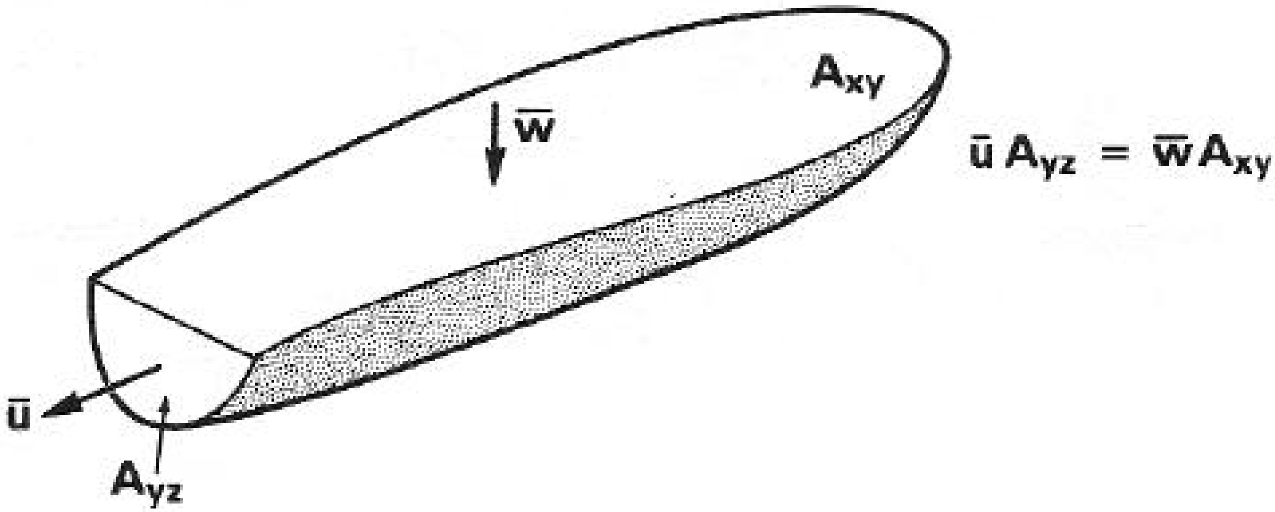
Term B: convergence of potential temperature flux by mean wind (**Advection**)

Term C: convergence of **Radiative Flux**

Term D: convergence of **Turbulent Sensible Heat Flux**

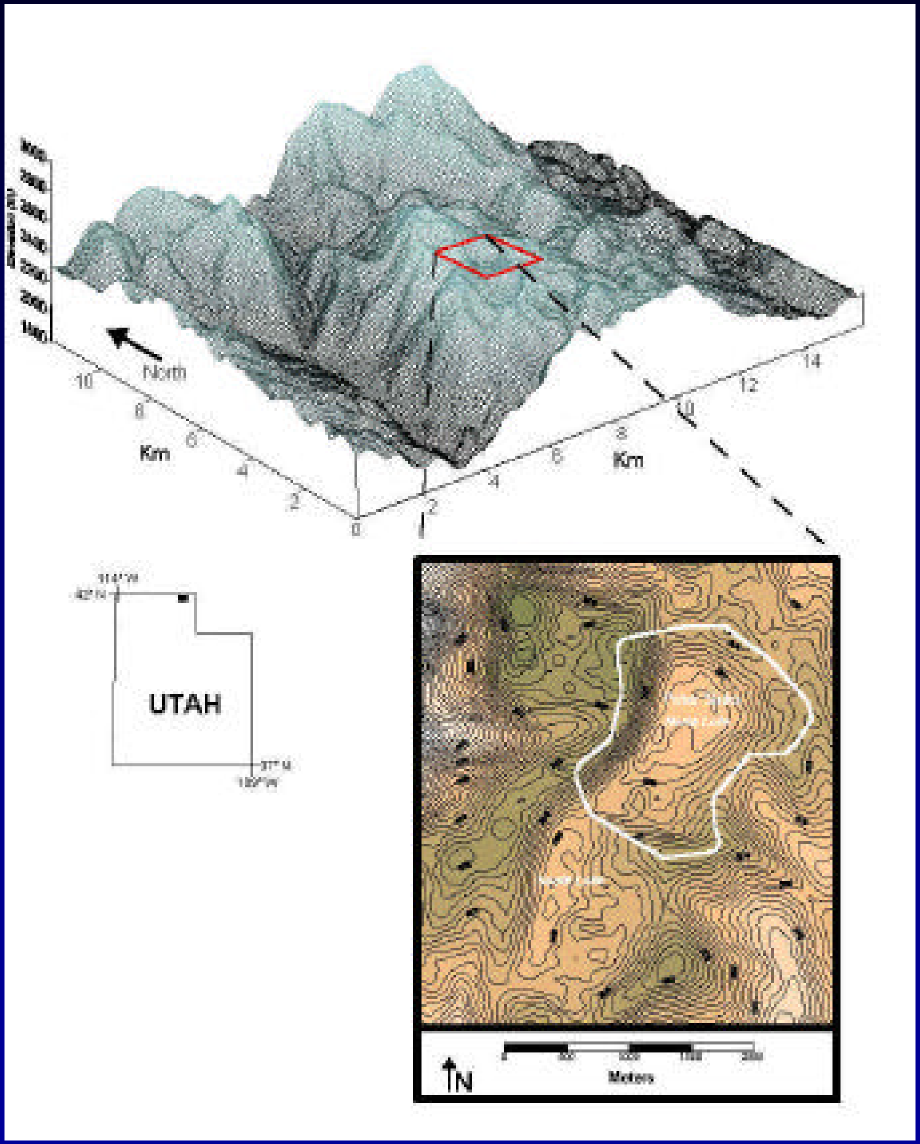


Mass conservation - valleys vs basins

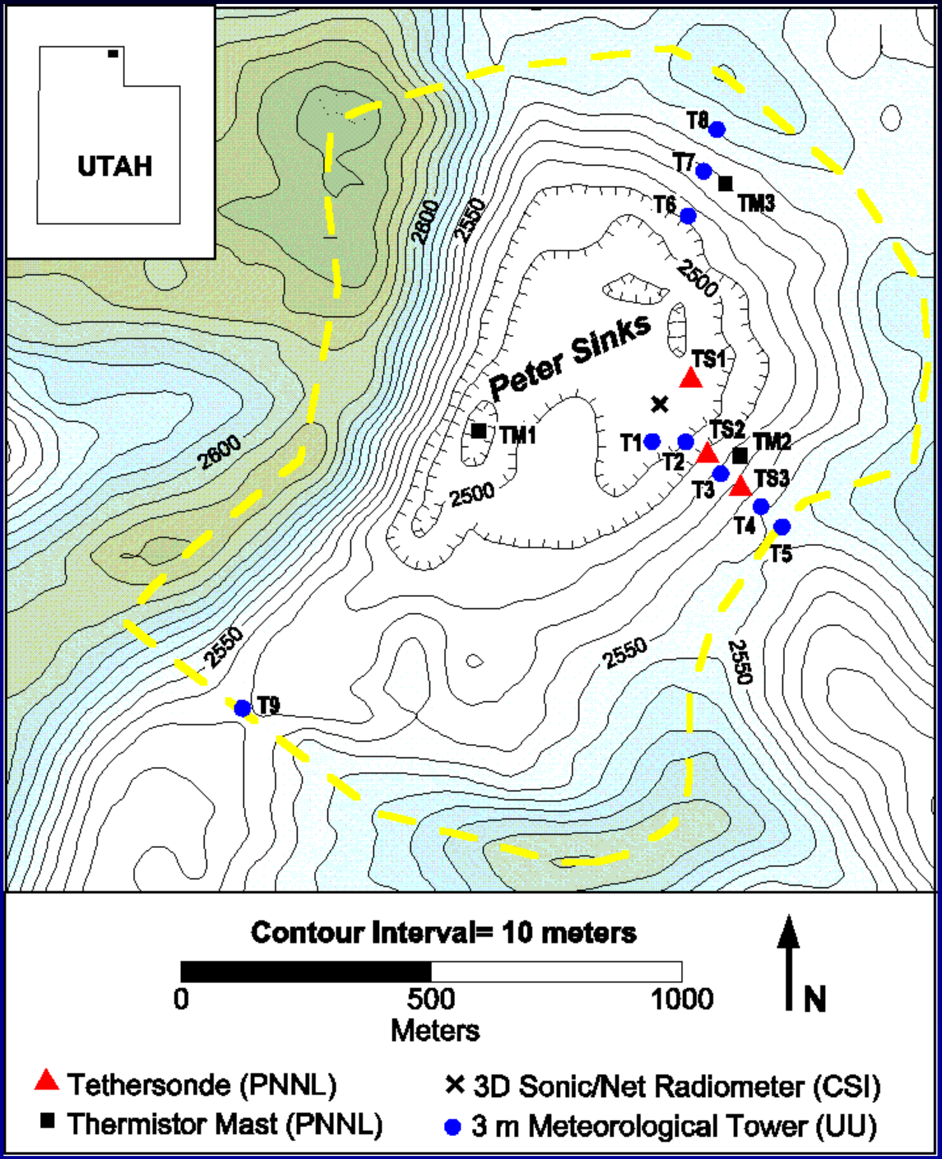


The Peter Sink - limestone sinkhole

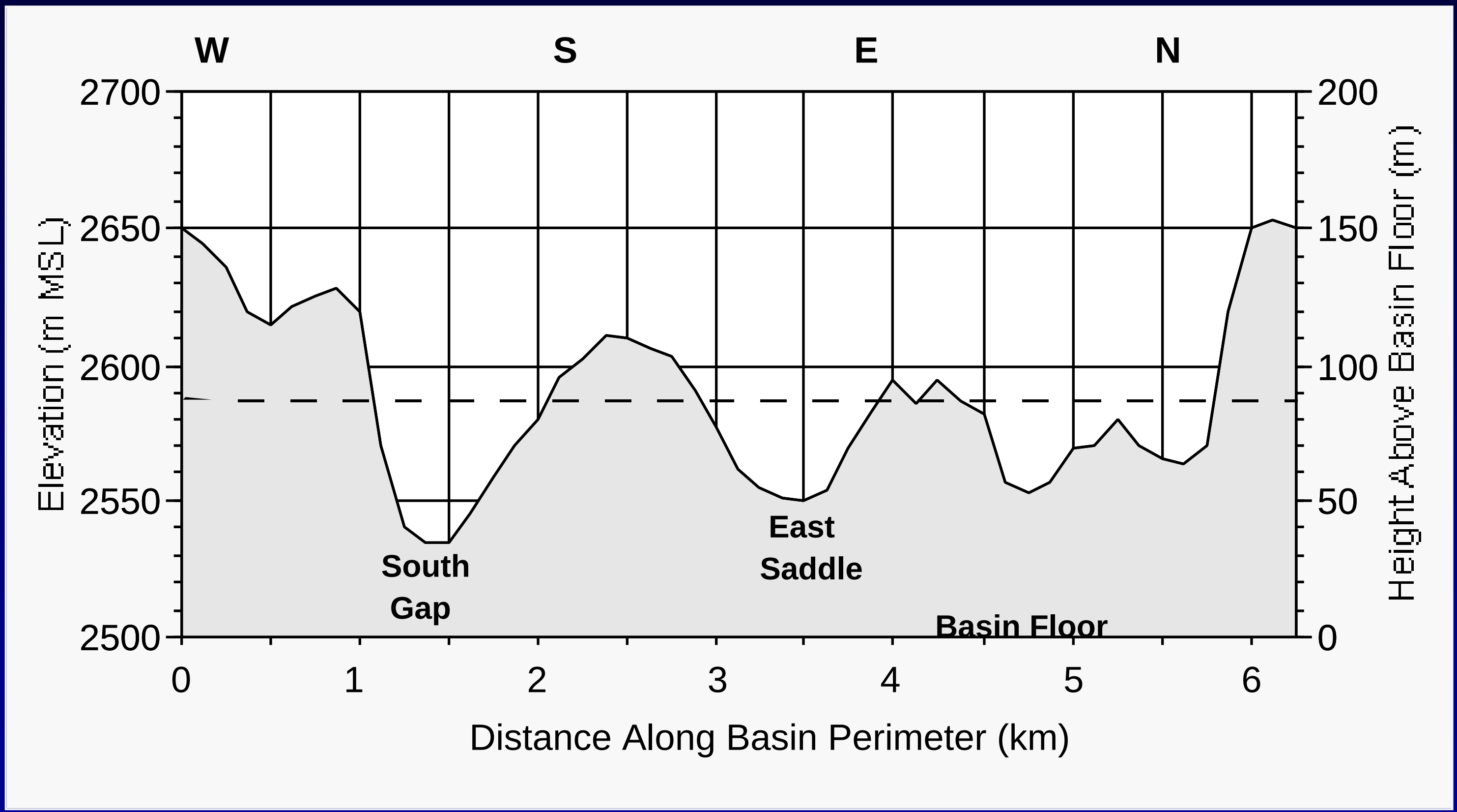
Map of Peter Sinks



Instrument locations



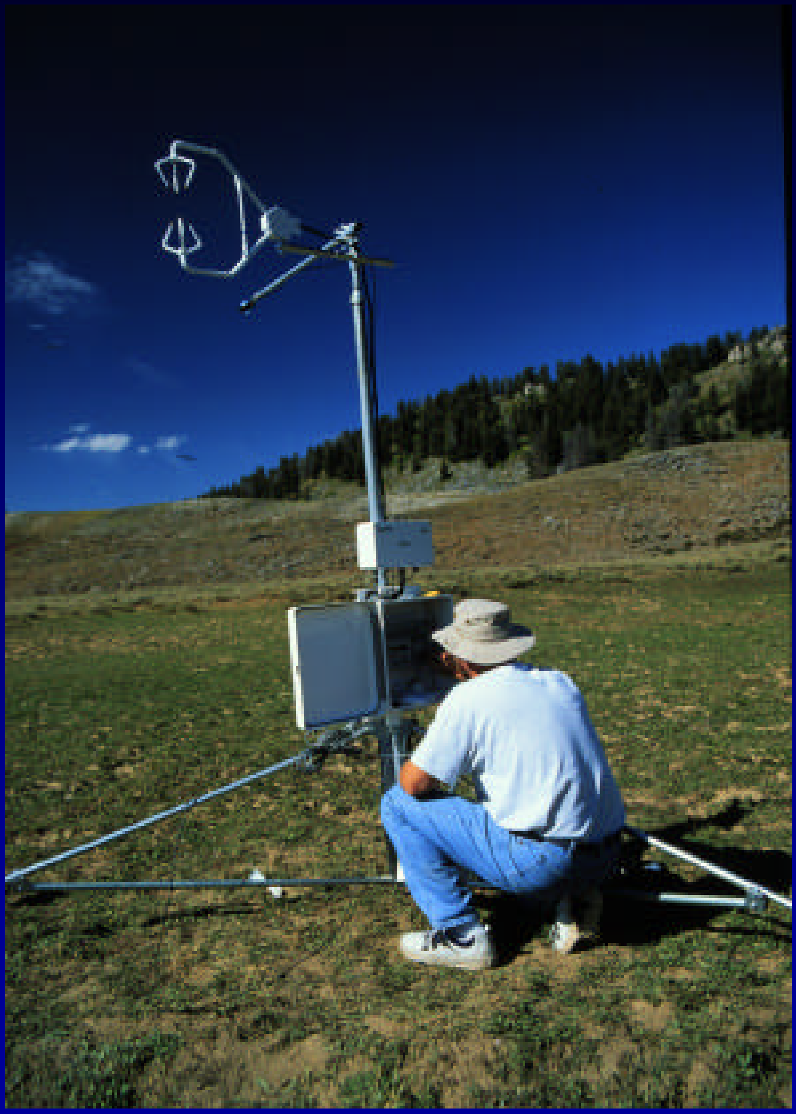
Peter Sinks ridgeline



Operations Base Tent

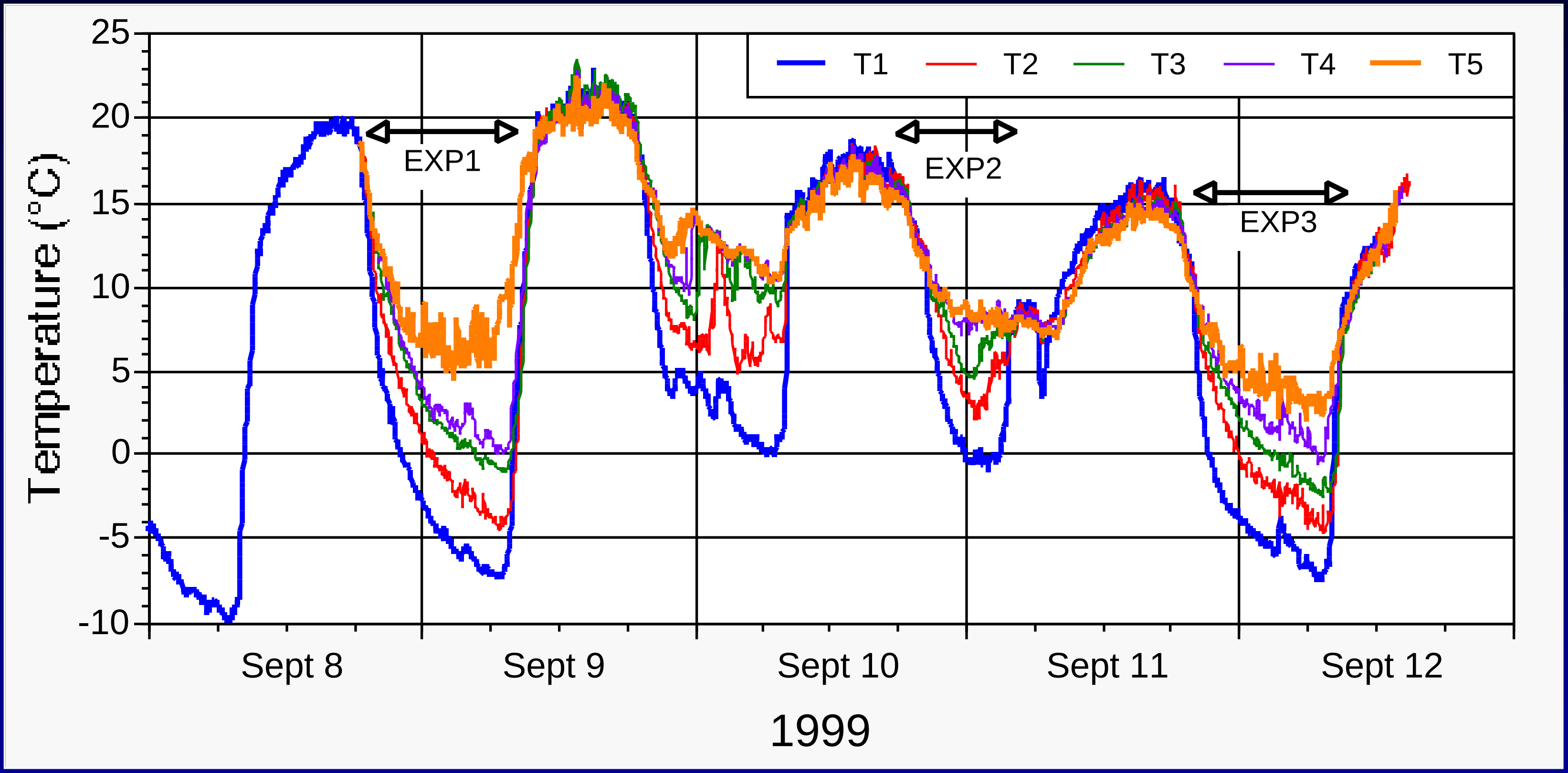
Tethersondes

Tethersonde, 3D sonic and net radiometer

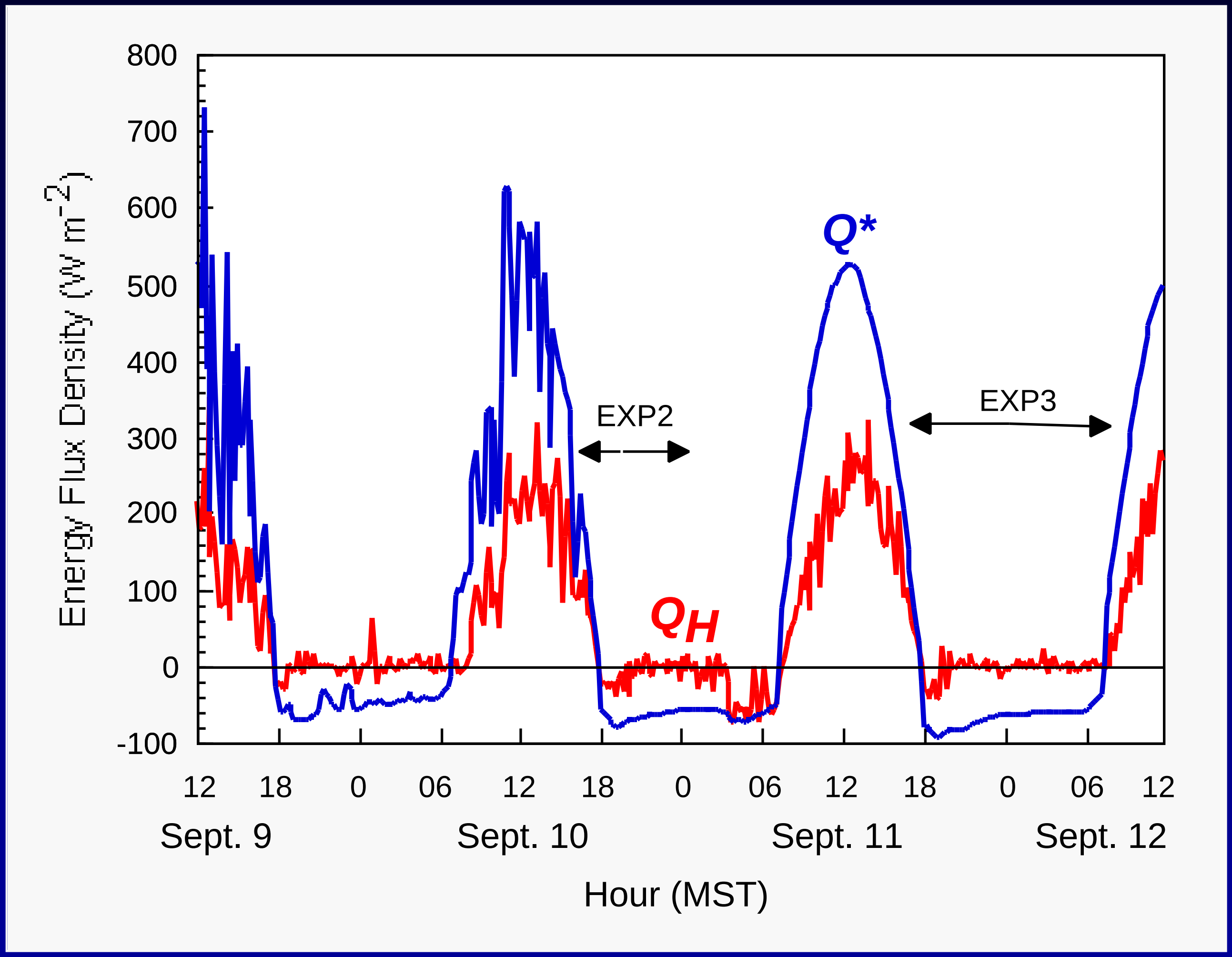


CSI weather station & thermocouple mast

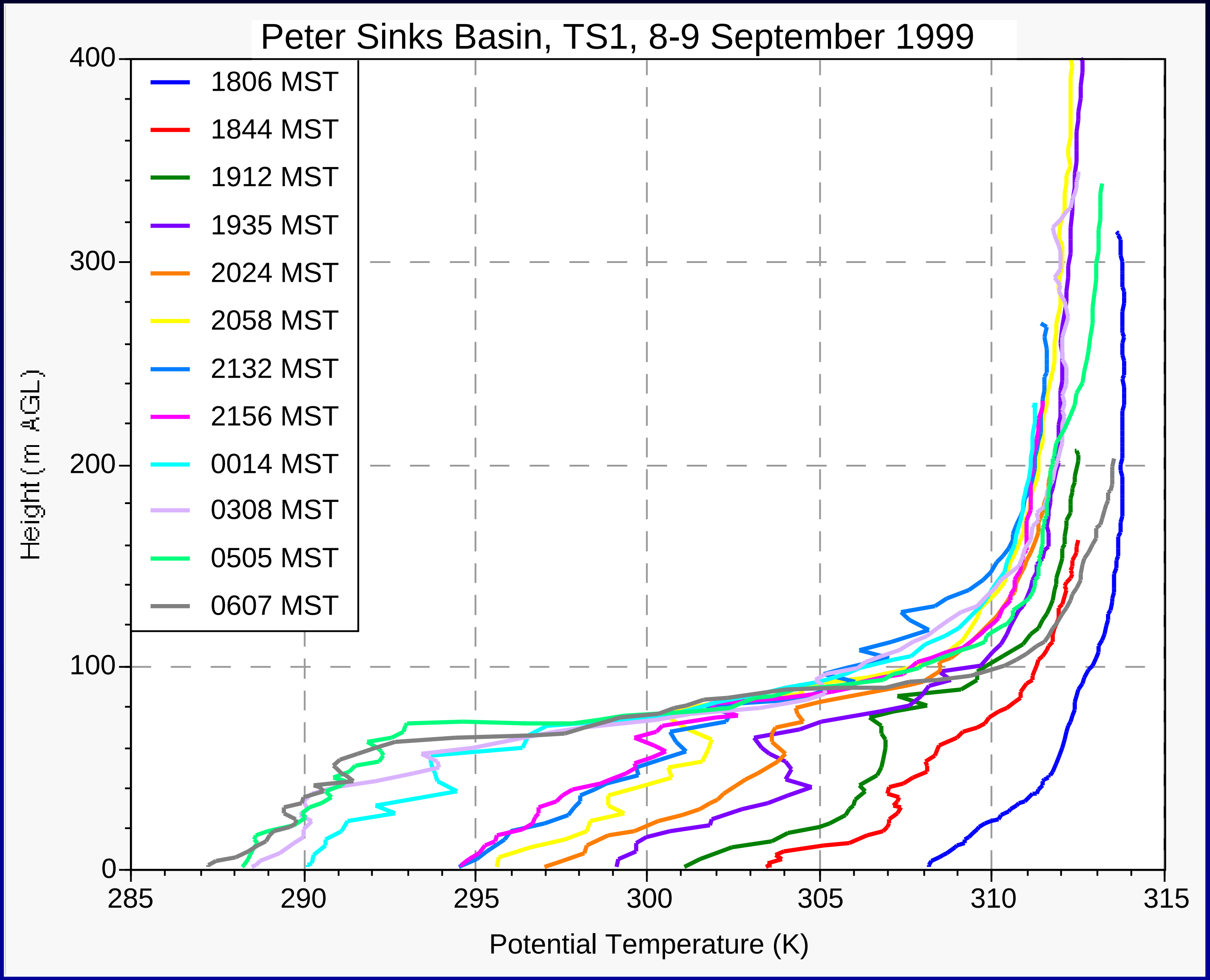
Temperature time series



Net radiation and sensible heat flux

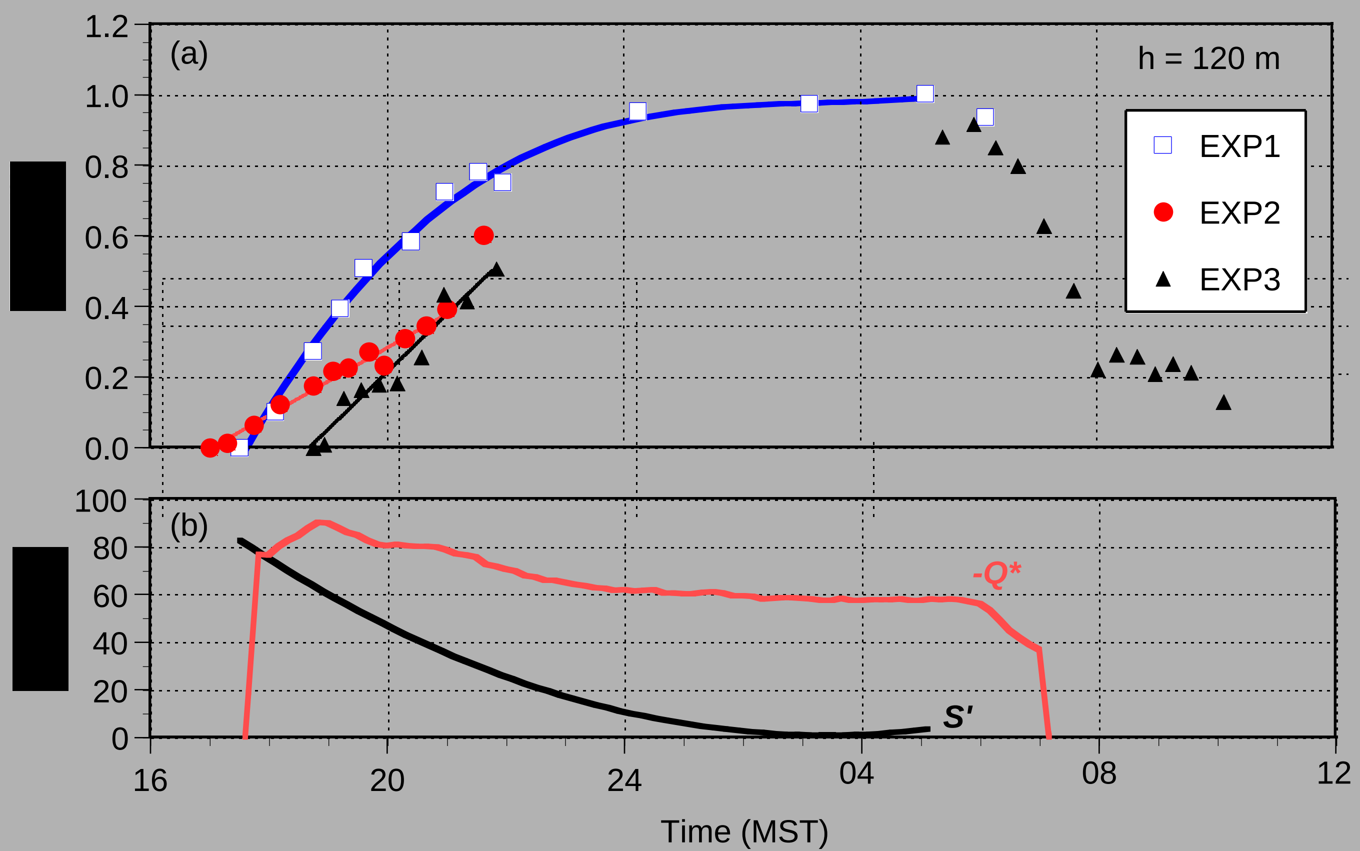


Potential temperature profiles at TS1

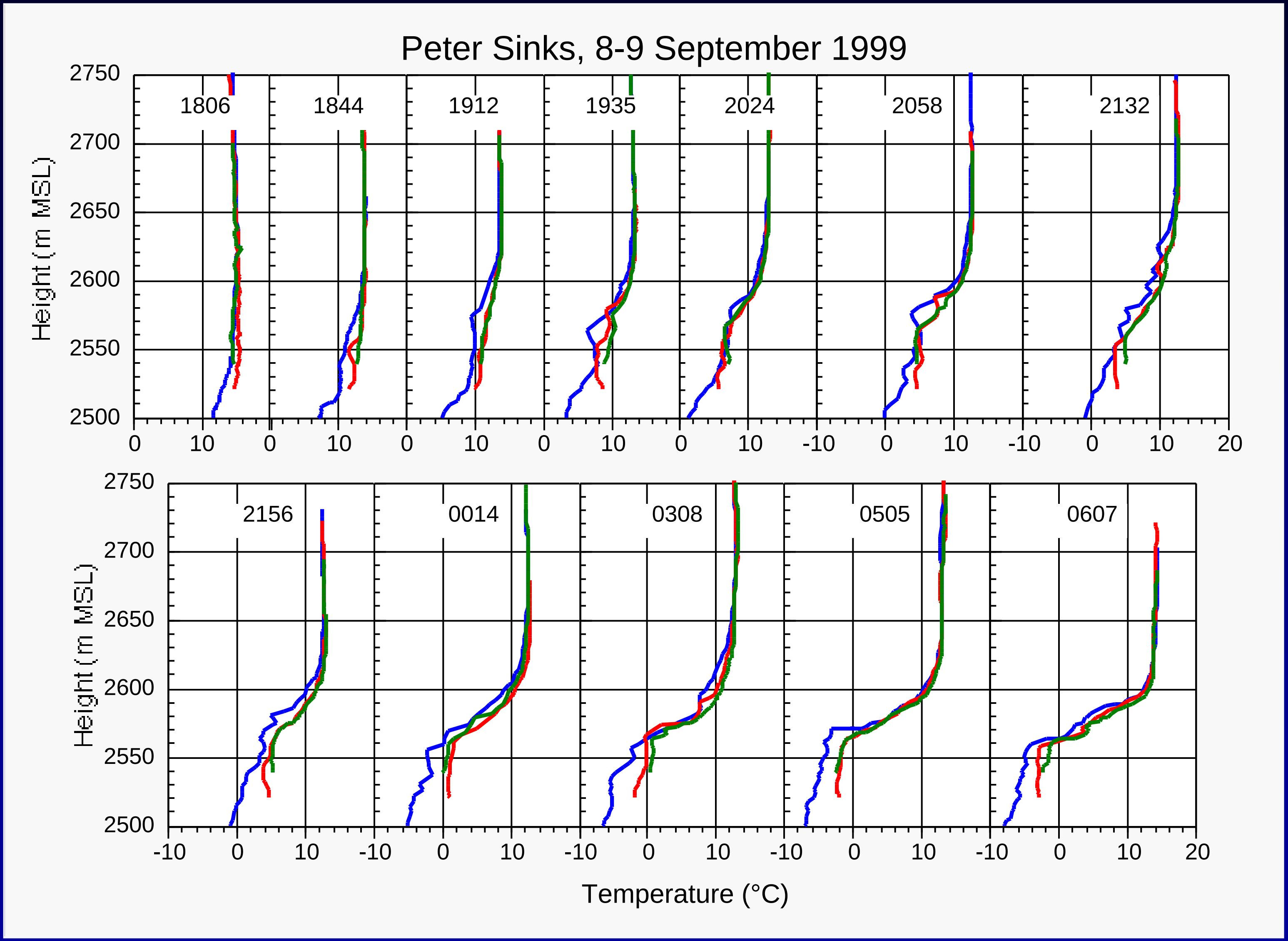


Accumulated Heat Losses from Peter Sinks

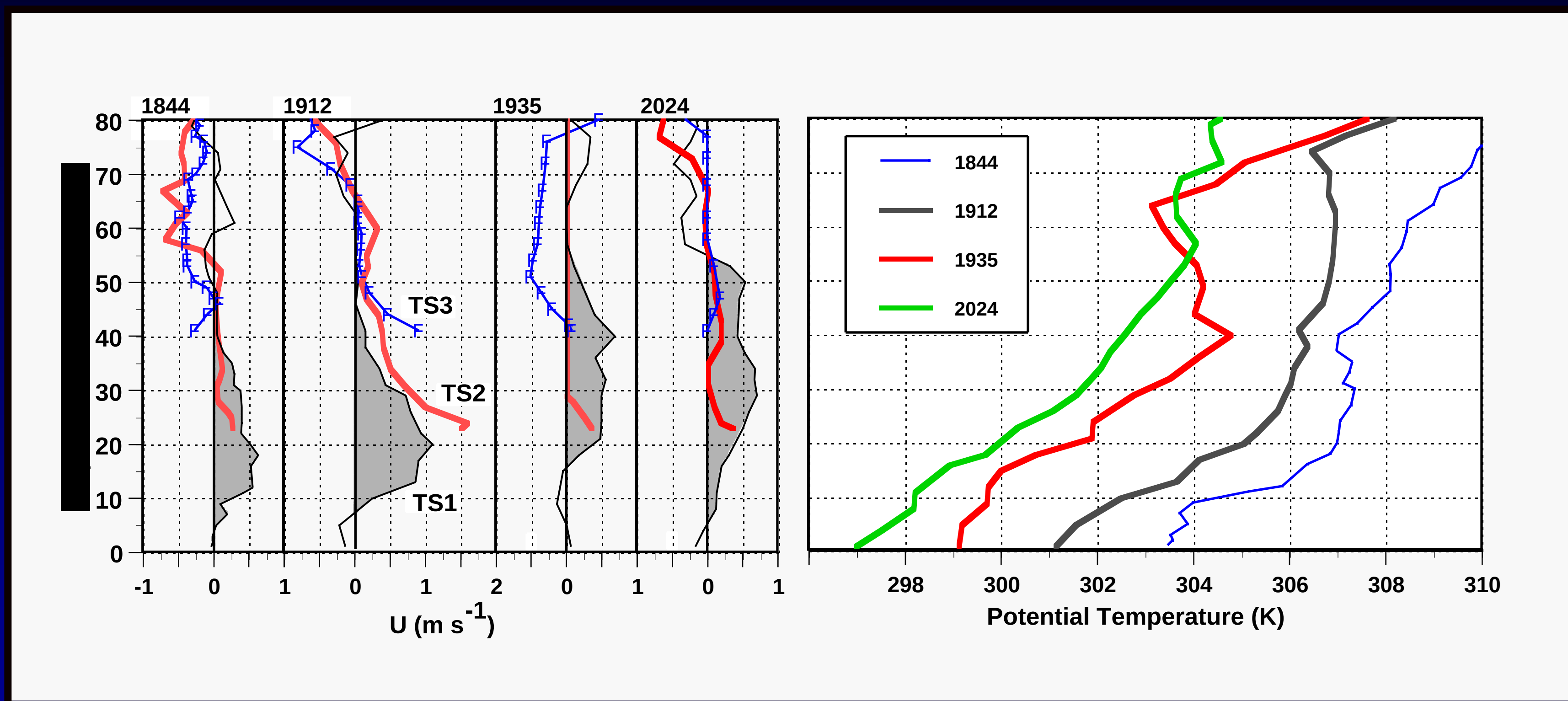
$$S = -\frac{\int_0^h c_p\ \rho(z)\,[\theta_0 - \theta(z)]\,A(z)\ dz}{A_h}$$



Synchronous temperature profiles



Observed Slope Flow Structure – Peter Sinks



Summary- from Peter Sinks Experiments

- Air over basin sidewall became warmer (1-5 K) than air over basin center- does not support continued slope flows.
- Formation of persistent superadiabatic layers within one of the most stable atmospheric structures on Earth!
- Downslope flows played minor role in cold pool formation.
- Heat loss from basin atmosphere is initially at the net rate of longwave loss, but decreases with time through night.

Monson Ranch Vineyard, WA